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Comparison Of Data Centric Protocols For WSN And Energy Enhanced M-SPIN (EEM-SPIN)

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Abstract

A Wireless Sensor Network consists of hundreds or thousands of sensor nodes that are deployed in a large geographical area. The efficiency of sensor networks depends on the routing protocols used. Routing protocols used for providing a best route from sensor nodes to sink node. In this paper the first part deals with comparison of data centric routing protocols SPIN, SPIN-1, M-SPIN for energy efficiency. As a result M-SPIN performs better than other two. M-SPIN is a better approach for the applications that need quick and reliable response. Second part of the paper deals with an enhanced version of M-SPIN protocol named Energy Enhanced M-SPIN (EEM-SPIN), and its performance is compared with the other protocols. EEM-SPIN proves better energy efficiency than other three protocols. The network simulator NS2 is used for the performance analysis.

1. Introduction

Efficient design and implementation of wireless sensor networks has become a hot area of research in recent years, due to the vast potential of sensor networks to enable applications that connect the physical world to the virtual world. By networking large numbers of tiny sensor nodes, it is possible to obtain data about physical phenomena that was difficult or impossible to obtain in more conventional ways. In future as advances in micro-fabrication technology allow the cost of manufacturing sensor nodes to continue to drop, increasing deployments of wireless sensor networks are expected, with the networks eventually growing to large numbers of nodes (e.g., thousands). Potential applications for such large-scale wireless sensor networks exist in a variety of fields, including medical monitoring, environmental monitoring, surveillance, home security, military operations, and industrial machine monitoring etc. Sensor network nodes are limited with respect to energy supply, restricted computational capacity and communication bandwidth. The ideal wireless sensor is networked and scaleable, fault tolerance, consume very little power, smart and software programmable, efficient, capable of fast data acquisition, reliable and accurate over long term, cost little to purchase and required no real maintenance.

1.1 Protocols for Wireless Sensor Network

The routing protocols used in the sensor networks are unique from the protocols used in other fixed networks. Sensor networks are infrastructure-less and there is no guarantee for reliable delivery. The nodes in the sensor networks are very prone to failure and there are different categories of routing protocols designed for wireless sensor networks. Wireless sensor network routing protocols are classified as data-centric, node-centric, location aware and quality of service based routing protocols.

1.2 Data-Centric Protocols

Data-centric protocols differ from traditional address-centric protocols in the manner that the data is sent from source sensors to the sink. In address-centric protocols, each source sensor that has the appropriate data responds by sending its data to the sink independently of all other sensors. However, in data-centric protocols, when the source sensors send their data to the sink, intermediate sensors can perform some form of aggregation on the data originating from multiple source sensors and send the aggregated data toward the sink. This process can result in energy savings because of less transmission required to send the data from the sources to the sink.

2. SPIN (Sensor Protocol for Information via Negotiation)

Negotiation [20] means before transmitting data, nodes negotiate with each other to overcome implosion and overlap, only useful information will be transferred, and observed data must be described by meta-data.

The performance of SPIN [16][19] is better than that flooding, gossiping and ideal protocol for energy and bandwidth consumption. Flooding, which broadcast the packet among all of its neighbours, Gossiping, a variant on flooding that sends messages to random sets of neighbouring nodes and ideal dissemination, an idealized routing protocol that assumes perfect knowledge and has the best possible performance. The traditional protocols which establish a path before transmit the data are also not suitable for the mobile sink. Because each time sink is changes its position. It needs to flood the data in order to reach at the sink node. Sensor Protocol for Information via Negotiation Protocol (SPIN) [20] nodes use three types of messages [22] ADV, REQ and DATA to communicate.

ADV – data advertisement, node that has data to share can advertise this by transmitting an ADV with meta-data attached
REQ –request for data, node sends a request when it wishes to receive some actual data
DATA – data message, contains actual sensor data with a meta-data header, data is much bigger than ADV or REQ messages.

ADV is used to advertise new data, REQ is also to request for data and DATA is the actual message. The protocol starts when a SPIN node [16] gets new data that it is willing to share on on-demand basis. It does so by broadcasting an ADV message containing metadata. Meta-data [20] size is very small as compared to the size of the DATA. If a neighbour is interested in the data, it sends an REQ message for the DATA and the DATA is sent back to this neighbour node. The neighbour sensor node then repeats this process to its neighbours till reach at the sink node.

One of the advantages of SPIN [20] is that topological changes are localized since each node needs to know only its single-hop neighbours. SPIN provides much energy savings than flooding and meta- data negotiation almost halves the redundant data. However, SPINs data advertisement mechanism cannot guarantee the delivery of data. To see this, consider the application of intrusion detection where data should be reliably reported over periodic intervals and assume that nodes interested in the data are located far away from the source node and the nodes between source and destination nodes are not interested in that data, such data will not be delivered to the destination at all.

SPIN protocol [22] is suitable to small or medium-sized WSN, and to bridges and other distribution environments. Therefore, SPIN [4] protocol is more effective and higher energy than some other protocols in a particular environment. SPIN protocol is an adaptive communication and data-centric routing protocol. In order to avoid the emergence of explosion of information and some overlap in flooding, the sensor nodes consult with each other through using metadata before transmitting data. So it succeeds in avoiding the blind use of resources and solving “implosion” and “overlap” problem in the flooding protocol [17], but the problem of “blind forward” and “data unaccessible” still exists and other issues maybe appear.

2.1 Blind Forward Problem

Source node will send the DATA packet [22] to all the neighbour nodes that respond. Nodes who have received data will broadcast ADV message to all of its neighbours in a similar way, and send DATA packets to its neighbour nodes that respond. This process is repeated until the packets reach the destination. If the network has a new data to be sent, it must repeat the process. So this method could lead to a “blind forward” problem. It is not only a waste of energy, but doesn’t take into account the balance of energy consumption of the network nodes.

2.2 Data Unaccessible Issue

In the SPIN protocol [22], if sensor nodes collect new data that need to be forwarded, it will directly broadcast ADV message to its neighbour nodes. In some cases, due to energy of itself, some nodes are reluctant to forward the new data; furthermore, a node’s neighbour nodes are not interested in the source of the data or they already have the data. In addition, there is an imbalance of energy consumption in the WSN. For the nodes around sink nodes, they locate on the only path of reaching the sink node, so they are bound to take more tasks and it is easy to run out of energy and fail. The problem above will result in data unaccessible in lossless network.

In SPIN, the blind forward problem will waste energy and shorten the life cycle of the network, and reduce network performance. The data unaccessible problem will lead to the network unable to collect information, and make the WSN lose the meaning of application.

3. SPIN 1

SPIN 1 will overcome the blind forward and data unaccessible problem. The working mechanism of SPIN 1 [41] is a negotiation process, which establishes a connection based on a three-way handshake.

Data broadcasting stage

When a sensor node (source node) has new data to send or forward, it first broadcasts ADV message to all its neighbors, and starts the timer. ADV message contains the metadata describing the data properties.

Data requesting stage

After the neighbors have received ADV message, they first determine if they have enough energy to complete the task of the three stages. If its energy value is below the threshold, it will not make any response; otherwise, it checks whether it already has the data. If it already has the broadcast data, then it sets the flag of REQ message to 1, and back its energy value to the source node by REQ message. In SPIN protocol, if the node has the data already, it won’t make any response. This point is also the biggest difference between SPIN 1 and SPIN. If the neighbors do not have the data but their energy is enough, in order to request to send data, the flag of REQ message will be set to 0, and back to the source node together with its energy value using the REQ message.

Data transmission phase

The source node updates its neighbour list according to the flag of REQ message it receives and energy values. In the threshold time, the source node judges nodes' flag in its neighbour list, if the flag in the neighbour list are both 1 or 0, then filters the nodes whose flags are 0 and forwards data to the node who has the largest energy value; if there are the same energy value, it will randomly select a node to forward; if all the flags of nodes are 0, chooses the node who has the largest energy value to forward the data. If the time is longer than threshold, and all the flags are 1, it is the point that "data unaccessible" problem appears, the source node selects a node who has the largest value from its neighbour list and forwards data mandatory, then removes nodes who do not send REQ message from the neighbour list.

3.1 Energy saving analysis of SPIN 1 Protocol

For the analysis of total energy needed for the process following parameters are used for any node in the network:
Size of the data that need to be transmitted: m bytes
Size of the ADV and REQ messages: L bytes
Energy needed to send a byte: Em
Energy needed to receive a byte: Er
Average number of neighbour nodes: N

Any node in the network will forward the data it receives to the next hop node. The steps of a node forwards M byte of data in the SPIN-1 are:

a) Send ADV messages, the energy consumption is (N-1) L Em
b) Receive the REQ Messages from N-1 nodes, the energy consumption is (N-1) L Er
c) Send (Data+L) bytes of data the energy consumption is (Data+L) Em

From the above, the total energy needed to receive a data and forward the same to the next hop node, the minimum energy consumption is
ESPIN-1 : Em (NL + L + m) + Er (L + NL + m)

4. M-SPIN (Modified SPIN)

M-SPIN [45] protocol to transmit information only to sink node instead of transmitting throughout the network. The protocol is based on SPIN family of protocol. In this proposed protocol, total number of packet transmissions is less. Therefore a significant amount of total energy can be saved.

Another interesting fact is that energy consumption not only depends on sensing the data but also on processing the sensed data and transmitting or receiving them to or from its neighbour nodes. So if it is possible to control number of transmission and receipt of messages, a significant amount of energy can be saved. An event that occurs in the WSN divides the entire network into two regions, A and B. Sensor nodes in region A are on the other side in the network in comparison with the sink node and sensor nodes in region B are on the same side and nearer to the sink node. Sensor nodes of region A can receive data from the event node, however, they will unnecessarily waste their energy in receiving or transmitting the data. In order to reach data to the sink node, data will have to travel more hops if they are sent via the nodes in region A. Thus, when an event occurs, it is always desirable that the data is sent through the nodes in region B. This would save the energy spent for transmission of a piece of data from an event node to the sink node. However, such selective transmission is not supported in the existing SPIN protocols.

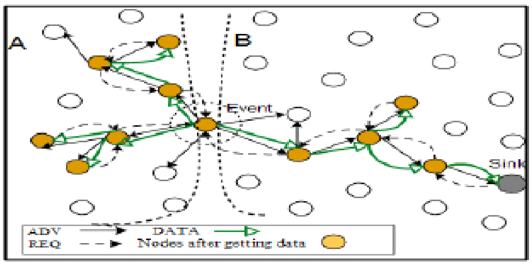


Figure 1 Data Transmission in M-SPIN

In few applications such as alarm monitoring applications need quick and reliable responses. Suppose in forest fire warning system, quick response is needed before any disaster occurs. In this case, it is desirable that data must be disseminated towards the sink node very quickly. M-SPIN routing protocol is better approach for such type of applications than SPIN.

Distance discovery

Distance discovery phase of M-SPIN [10][45], hop distance is measured from sink nodes. Initially the sink node broadcasts startup packet in the network with type, node Id and hop. Here type means type of messages. The nodeId represents id of the sending node

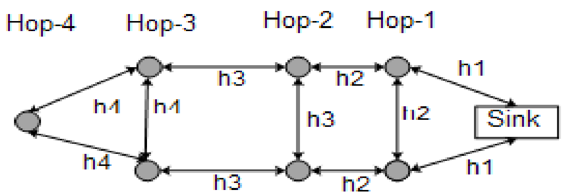


Figure 2 Distance Discovery Phase

and hop represents hop distance from the sink node. Initial value of hop is set to 1. When a sensor node receives the Startup packet, it stores this hop value as its hop distance from the sink node in memory. After storing the value, the sensor node increases the hop value by 1 and then re- broadcast the Startup packet to its neighbour nodes with modified hop value. It may also be possible for a sensor node to receive multiple Startup packets from different intermediate nodes. Whenever a sensor node b receives Startup packets from its neighbors ai, $1 \leq i \leq n$, it checks the hop distances and set the distance to the minimum. This process is continued until all nodes in the network get the Startup packets at least once within the Distance discovery phase. After successful completion of this phase, next phase will be started for negotiation. StartupMsg structure contains three member variables. HopTable structure contains only one member called hop_t to store the hop value at each node.

Negotiation

The Negotiation phase is almost similar to the SPIN protocol. The source node sends an ADV message. Upon receiving an ADV message, each neighbour node verifies whether it has already received or requested the advertised data. Not only that, receiver node also verifies whether it is nearer to the sink node or not in comparison with the node that has sent the ADV message. This is the main difference between the negotiation phase of SPIN and that of M-SPIN. If hop distance of the receiving node (own_hop) is less than the hop distance received by it as part of the ADV message (rcev_hop), i.e. own_hop < rcev_hop, then the receiving nodes send REQ message to the sending node for current data. The sending node then sends the actual data to the requesting node using DATA message. The data packet contains the hop distance value along with the information about the event.

Data Transmission

Data transmission phase is same as SPIN protocol. After request is received by the source node, data is immediately sent to the requesting node. If the requesting nodes are intermediate nodes other than the sink node then the Negotiation phase repeats. Thus, the intermediate sensor nodes broadcast ADV for the data with modified hop distance value. The sending nodes modify the hop distance field with its own hop distance value and add that in packet format of the ADV message. The process continues till data reaches the sink node.

5. Result of the Comparison: SPIN, SPIN 1 and M-SPIN

Both the SPIN 1 and the M-SPIN protocols consume lesser energy than SPIN. But the SPIN 1 consumes relatively higher power than M-SPIN. Simulations are performed to understand the energy consumption for the broadcast data transmission.

In M-SPIN, only the nodes which are nearer to sink node send REQ packets in response to ADV packet from the source node. This helps the messages reach faster to the sink node using the hop value fixed in the distance discovery phase. In M-SPIN, total number of ADV, REQ and the data messages needed for the transmission of the data come down and this helps in the reduction of energy needed for the transmissions. Hence the energy needed for the transmission is reduced in M-SPIN compared to the SPIN-1. This is possible only because of the introduction of the distance discovery phase introduced in the M-SPIN protocol.

But one problem in M-SPIN is that few sensor nodes may be used several times and those nodes may dissipate energy and may be destroyed earlier than other nodes in the network.

6. Proposed EEM-SPIN Protocol

To overcome the problem faced in the M-SPIN protocol, an enhanced version of the M-SPIN protocol called Energy Enhanced M-SPIN (EEM-SPIN) is proposed. EEM-SPIN uses cluster methodology and dynamic cluster head election to overcome the problem of using only few nodes for the forwarding of the data. For the formation of clusters and the election of cluster heads the Weighted Cluster Algorithm (WCA) is used.

A cluster [8] is a small group or bunch of sensor nodes. Cluster-based control structures provide more efficient use of resources for large dynamic networks. Clustering can be used for Transmission management (link-cluster architecture), Backbone formation and Routing efficiency. Cluster heads acts as routers and forwards packets from one node to another and its responsible for resource allocation and maintains network topology, it aware of its cluster members and one-hop neighbouring cluster heads.Since cluster heads decide network topology, the election of cluster heads is optimally critical.

6.1 Weighted Clustering Algorithm (WCA) steps for Cluster Head Election

1. Compute the degree dv each node v

$$d_v = |N(v)| = \sum_{v' \in V, v' \neq v} \{dist(v, v') < tx_{range}\}$$

Coordinate distance, predefined transmission range.

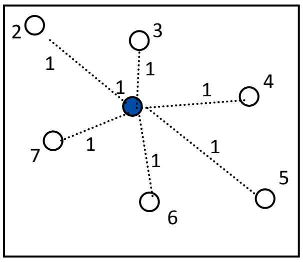
2. Compute the degree-difference for every node

$$\Delta_v = |d_v - \delta|$$

For efficient MAC (medium access control) functioning. Upper bound on # of nodes a cluster head can handle.

3. Compute the sum of the distances Dv with all neighbours

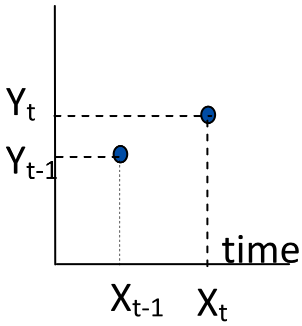
$$D_v = \sum_{v' \in N(v)} \{dist(v, v')\}$$



Energy consumption: more energy for greater distance communication. Power required to support a link increases faster than linearly with distance.

4. Compute the average speed of every node; gives a measure of mobility Mv

$$M_v = \frac{1}{T} \sum_{t=1}^{T} \sqrt{(X_t - X_{t-1})^2 + (Y_t - Y_{t-1})^2}$$



where (X_t, Y_t) and (X_{t-1}, Y_{t-1}) are the coordinates of the node v and t at time $(t-1)$ Component with less mobility is a better choice for cluster head.

5. Compute the total (cumulative) time Pv a node acts as cluster head

Battery drainage = Power consumed

6. Calculate the combined weight Wv for each node Wv = w1Δv + w2Dv + w3Mv + w4Pv

7. Find min Wv, choose node v as the cluster head, remove all neighbours of v for further WCA

8. Repeat steps 2 to 7 for the remaining nodes

The basic idea is to combine each of the above system parameters with certain weighing factors depending on the system needs. The flexibility of changing the weighting factors (w1, w2, w3 and w4) helps in applying the algorithm to various networks. The nodes with lowest combined weights (Wv) are elected as the cluster heads.

The following figures show the steps involved in converting the scattered nodes to clusters and the election of the cluster heads.

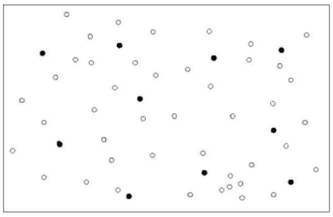


Figure 3 Cluster heads Identification

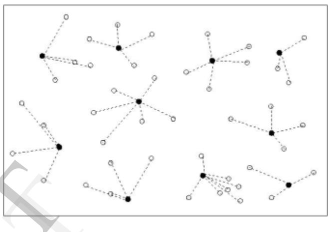


Figure 4 Clusters are formed

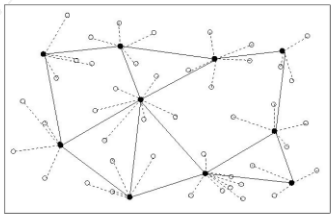


Figure.5 Clusters are connected

6.2 Benefits of the EEM-SPIN

Avoids the problem of sensors destroyed earlier than other nodes due to usage of few sensor nodes for several transmissions. Increase in the network lifetime due to the introduction of dynamic election of cluster heads. Clustering technique is used in the EEM-SPIN and the cluster heads are elected using Weighted Clustering Algorithm (WCA). By these enhancements the problem of few nodes used several times for transmission is avoided. Performance of the cluster based network formed using the above algorithm will be analyzed and compared against the M-SPIN and the SPIN 1 and SPIN protocol implementations.

7. Simulation Results Analysis

In this section the results of the simulation performed for the different protocols are presented and the comparison analysis is performed. The following figures give the energy consumption for different protocols. The simulation for the energy consumption by a node for different protocols was performed for 200 seconds and the results are plotted as a graph. From the graphs, it can be concluded that SPIN needs much higher energy than other protocols. SPIN 1 consumes lesser energy than SPIN but the energy consumption is higher than M-SPIN. The EEM-SPIN consumes the least energy of all the protocols

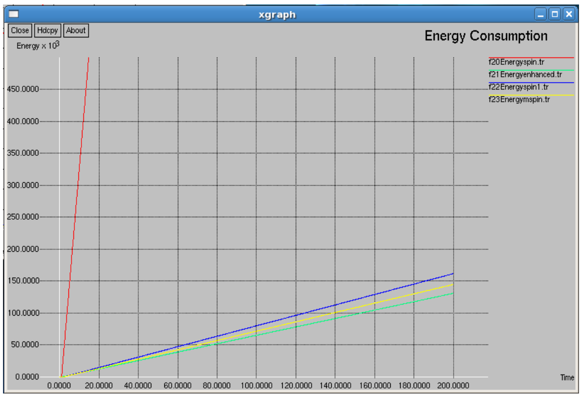


Figure 6 Simulation Results Graph for different protocols (200sec)

Figure gives the energy consumption for different protocols versus the time for which the network is simulated. The network is simulated for 200 seconds to obtain the energy consumption. From the above figure, it can be found that the SPIN needs much higher energy than other protocols and the EEM-SPIN needs least energy than other protocols.

The figure shows the Network Animator window for the simulation of the M-SPIN protocol.

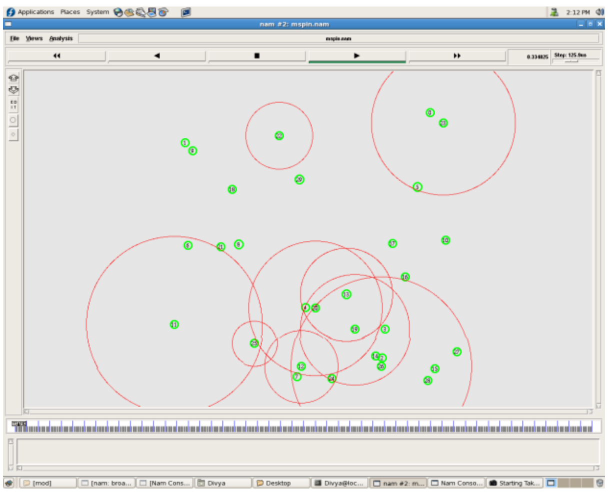


Figure 7 Network Animator Windows for M-SPIN

8. Conclusion and Future work

In this research work, an energy enhanced version of the M-SPIN (EEM-SPIN) protocol has been proposed using weighted clustering algorithm (WCA) for WSN. It has the flexibility of assigning different weights and takes into account a combined metrics to form clusters automatically. Limiting the number of nodes inside a cluster allows restricting the number of nodes catered by a cluster head so that it does not degrade the MAC functioning. For a fixed cluster head election scheme, a cluster head with constrained energy may drain its battery quickly due to heavy utilization. In order to spread the energy usage over the network and achieve a better load balancing among cluster heads, re-election of the cluster heads may be a useful strategy.

EEM-SPIN utilizes factors like the node degree, remaining battery power, and node mobility for the cluster heads' election. Such approach provides a reliable method of cluster organization for WSN. Simulation results indicated that the model agrees well with the behaviour of the algorithm. The EEM-SPIN algorithm showed that the performance is better than SPIN, SPIN-1 and M-SPIN algorithms in the power strategies and the simulation set up showed the increase in the life time of a WSN.EEM-SPIN avoids the problem of sensors destroyed earlier than other nodes due to usage of few sensor nodes for several transmissions and increases the network lifetime due to the introduction of dynamic election of cluster heads. Clustering technique is used in the EEM-SPIN and the cluster heads are elected using Weighted Clustering Algorithm (WCA). By these enhancements the problem of few nodes used several times for transmission is avoided.

Though the performance of the EEM-SPIN is better than other protocols analyzed, it may be possible to reduce the energy consumption for the cluster head elections. In future it may be possible to work in this problem by using different clustering algorithms that may be better suitable for the WSN.

9. References

[1] Akkaya, K., and Younis, M. (2005), "A Survey on Routing Protocols for Wireless Sensor Networks", Elsevier Journal of Ad Hoc Networks, Vol. 3, pp. 325-349.

[2] Akyildiz, I.F., Vuran, M.C., Akan, O., and Su, W. (2004), "Wireless Sensor Networks:A Survey Revisited", Elsevier Journal of Computer Networks, Vol. 45, No. 3.

[3] Akyildiz,I.F.,Su, W., Sankarasubramaniam, Y., and Cayirci, E., (2002), "Wireless sensor networks: a survey", Elsevier Journel of Computer Networks, Vol. 38, No. 4, pp. 393-422.
[4] Al-Karaki, J.N., Kamal, A.E., (2004), "Routing Techniques in Wireless Sensor Networks: A Survey", IEEE transactions on Wireless Communications, Vol.11, No. 6, pp. 6-28.
[5] Akyildiz,I.F.,Su,W., Sankarasubramaniam, Y., and Cayirci, E., (2002), "A survey on sensor networks", IEEE Communications Magazine, Vol. 40, No. 8, pp.102-114.
[6] Azni, A.H., Madihah Mohd, S., Azreen, A., and Ariff Syah, J., (2009), "Performance Analysis of Routing Protocol for WSN Using Data Centric Approach", World Academy of Science, Engineering and Technology, Vol. 53.
[7] Basagni, S., (1999), "Distributive and Mobility-Adaptive Clustering for Multimedia Support in Multi-hop Wireless Networks", Proceedings of Vehicular Technology Conference, VTC, Vol. 2, pp. 889-893.
[8] Chatterjee, M., Das, S.K., and Turgut, D., (2002), "WCA: A Weighted Clustering Algorithm for Mobile Ad Hoc Networks", Cluster Computing Journal, Vol. 5, No. 2, pp. 193-204.
[9] Chee-Yee Chong, C., and Srikanta, P., (2005), "Sensor Networks: Evolution, Opportunities, and Challenges", IEEE Tranactions on sensor networks, Vol. 28, pp.117-123.
[10] Deepak, P., and Bibhudatta, S., (2010), "Adaptive Protocol for Critical Data Transmission of Mobile Sink Wireless Sensor Networks", International Journal of Computer Science, Vol.10.
[11] Energy Harvesting Projects, (2005), "Collections of articles on IEEE Pervasive Computing", pp. 69-71.
[12] Estrin, D., Girod, L., Pottie, G., and Srivastava, M., (2001), "Instrumenting the world with wireless sensor networks", Proc. Acoustics, Speech, and Signal Processing, Vol. 4, pp. 2033–2036.
[13] Farhana, Z., (2007), "REEP : a data-centric, reliable and energy-efficient routing protocol for wireless sensor networks", Digital Commons @ Ryerson.
[14] Garcia-Hernandez, C.F., Ibargüengoytia-González, P.H., Garcia-Hernandez, J., and Pérez-Díaz, J.A., (2007), "Wireless Sensor Networks and Applications: a Survey", International Journal of Computer Science and Network Security, Vol.7, No.3.
[15] Hernzelmen, W., and Kulik, J., (1999), "Adaptive protocols for information dissemination in wireless sensor networks", ACM/IEEE Mobicom Conference, Seattle, WA, pp. 174-185.
[16] Heinzelman, W., Chandrakasan, A., and Balakrishnan, H., (2000), "Energy-Efficient Communication Protocol for Wireless Sensor Networks", Proceeding of the Hawaii International Conference System Sciences, Hawaii, USA.
[17] Heinzelman, W.R., Chandrakasan, A., and Balakrishnan, H., (2000), "Energy-efficient Communication Protocol for Wireless Microsensor Networks", IEEE Computer Society Proceedings of the Thirty Third Hawaii International Conference on System Sciences, Vol. 8, p. 8020.
[18] 21 ideas for the 21st century, (1999), Business Week, pp. 78-167.
[19] Jonna, K., Rabiner, W., and Hari Balakrishanan, (2002), "Negotiation based protocols for Disseminating information in Wireless Sensor Networks", ACM Wireless Networks.
[20] Kulik, J., Heinzelman, W.R., and Balakrishnan, (2002), "Negotiation–Based Protocols for Disseminating Information in Wireless Sensor Networks", Wireless Networks, Vol. 8, pp. 169-185.
[21] Luis, J., Ana Lucila, S., Alicia, T., Cabrera, S., and Barenco Abbas, C.J., (2009), "Routing Protocols in Wireless Sensor Networks", Sensors 2009.
[22] Luwei, J., Liu, F., and Li, Y., (2011), "Energy Saving Routing Algorithm Based on SPIN Protocol in WSN", IEEE Tranactions on wireless sensor networks.
[23] Li, L., and Wu, F., (2007), "Research on SPIN of wireless sensor network", Computer and Modernization, Vol. 3, pp. 93-96.
[24] Mainak, C., Sajal, K., Damla,T., (2002), "WCA: A Weighted Clustering Algorithm for Mobile Ad Hoc Networks", Cluster Computing, Vol. 5, pp.193–204.
[25] Munish, B., Kotary, D.K., and Soni, S., (2012), "Comparative analysis of energy efficient routing protocol for wireless sensor network", International journal of computer application on wireless communication and mobile networks, No. 14, pp.65-69.
[26] Mudholkar, R.R., Sawant, S.R., and Patil, V.C., (2012), "Classification and compersion of routing protocols in wireless sensor networks", Ubicc journal, Vol. 4, pp.704-711.
[27] Obaisat, Y., and Braun, R., (2003), "On Wireless Sensor Networks: Architectures, Protocols, Applications, and Management".
[28] Padmanabhan, K., and Kamalakkannan, P., (2011), "A Study on Energy Efficient Routing Protocols in Wireless Sensor Networks", European Journal of Scientific Research, Vol. 60, No. 4, pp. 499-511.
[29] Rajashree, V., Biradar, V.C., Sawant S.R., and Mudholkar, R.R., (2012), "Classification and comparison of Routing Protocols in Wireless Sensor Networks", Ubiquitous Computing Security Systems Journal, Vol. 4, pp. 704-711.
[30] Romer, K., and Mattern, F., (2004), "The design space of wireless sensor networks", IEEE

transactions on Wireless Communications, Vol. 11, No. 6, pp. 54-61.
[31] Schurgers , C., and Srivastava, M. B., (2001), "Energy Efficient Routing in Wireless Sensor Networks", MILCOM Proceedings on Communications for Network-Centric Operations: Creating the Information Force, McLean, VA.
[32] Shi, Y. B., Ye, X. B., and Liu, P. L., (2005), "Research status on wireless sensor networks", Foreign Electronic Measurement Technology, Vol. 24, No. 1, pp. 19-23.
[33] Singh, S.K., Singh, M.P., and Singh, D.K., (2010), "A survey of Energy-Efficient Hierarchical Cluster based Routing in Wireless Sensor Networks", International Journal of Advanced Networking and Application, Vol. 02, No. 02, pp. 570–580.
[34] Singh, S.K., Singh, M.P., and Singh, D.K., (2010), "Routing Protocols in Wireless Sensor Networks – Survey", International Journal of Computer Science and Engineering Survey, Vol. 1, No. 2.
[35] Shanmugam, A., and Chandrasekaran, V., (2012), "A review on hierarchical cluster based routing in wireless sensor networks", Journal of global research in computer science, Vol. 3, pp.12-16.
[36] Singh, D., Choudhary, N., and Pandey, S., (2012), 'Performance analysis of energy efficient clustering algorithims for wireless sensor networks", International journal of computer applications,Vol. 5, No. 12, pp.56-59.
[37] Syah Johari, A., Madihah Mohd Saudi, M.M., and Azreen, A., (2009), "Performance analysis of routing protocols for WSN using data centric approach", World academy of Science, Engineering and Technology, Vol. 12.
[38] Su, M., and Sankarasubramaniam, Y., (2002), "Wireless sensor network: a survey", Broadband and Wireless Networking Laboratory, School of Electrical and Computer Engineering, Atlanta, pp. 393-442.
[39] Stankovic, A., (2006), "Wireless Sensor Networks",University of Virginia Charlottesville.
[40] Vibhav, K.S., Imam, S.A., and Beg, M.T., (2012), "Energy efficient communication methods in wireless sensor networks-review", International journal of computer applications, Vol. 39, No. 17.
[41] Wu, F., and L. Li., (2007), "Research on SPIN of wireless sensor network", Computer and Modernization, Vol. 3, pp. 93-96.
[42] Younis, M., Youssef, M., and Arisha, K., (2002), "Energy-aware Routing in Cluster-Based Sensor Networks", Proceedings of the 10th IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems.
[43] Ying Miao, (2005), "Applications of sensor networks", Journal of Computer Networks and Communication Systems, pp. 27-34.
[44] Zabin, F., Misra, S., Woungang, I., Rashvand, H.F., Ma, N.W., and Ali, M. A., (2007), "REEP: data-centric, energy-efficient and reliable routing protocol for wireless sensor networks". IET Communications on wireless sensor networks. Vol. 2, No. 8, pp. 995-1008.

[45] Zeenat, R., Sarbani, R., and Nandini, M., (2011), "A Modified SPIN for Wireless Sensor Networks", IEEE transactions on wireless sensor networks Vol. 11, pp 978-982.